Activities of the neutron standardization at the Korea Research Institute of Standards and Science (KRISS)

I. Introduction

The activities of neutron standardization in KRISS have been continued for last 20 years. The neutron emission rate measurement standard, and the radionuclide neutron source based fluence standards are established. Recently, we started the neutron spectrometry using Bonner Sphere Spectrometer and we plan to measure the neutron spectra at the work place of the nuclear power plant.

We joined two international comparison exercises for last several years and we are willing to join future international comparisons as much as we can.

II. Establishment and maintenance of neutron standards

1. Absolute measurement of Neutron Emission rate of radionuclide neutron sources

Manganese Sulfate Bath was installed at KRISS in 1988 and used as a primary standard for the absolute measurement of Neutron Emission rate of radionuclide neutron sources. The diameter of the bath is 125 cm and the volume of the bath is 1.0226×10^6 cm^3. The aqueous solution of Manganese sulfate is circulated with the flow rate of ~10 cc/minute to the position of the gamma detector (NaI (Tl) crystal of 1.5" × 1.5").

The counting efficiency of the system is determined using the standard ^{56}Mn radioisotope. The ^{56}Mn radioisotopes are produced by the research reactor and the specific activity is determined by 4πβ-ɣ(PPC) coincidence method, which is the KRISS primary standard.

The various corrections to determine the emission rate were determined by the direct measurements and the calculations based on the cross sections. But, recently, all the corrections are replaced with the MCNP calculation.
Now, we can measure the neutron emission rate of the order of 10^5/s to 10^8/s with the uncertainties of the order of 0.7%. The neutron emission rate measurement has the traceability to the activity standards of KRISS.

2. Radionuclide source based fluence standards

KRISS has the neutron irradiation room with the size of $6.7 \times 7.6 \times 6.4$ m^3 and the neutron sources of bare ^{252}Cf (~10^6 n/s, ~10^8 n/s), D_2O moderated ^{252}Cf, ^{241}Am-Be (~10^5 n/s, ~10^7 n/s) can be installed at the center of the room. The strongest source (^{252}Cf with the neutron emission rate of ~10^8 n/s) can be controlled remotely. The moving arms for the calibration and test of the neutron detector can be moved about 2 m (the minimum distance from the source is ~20 cm).

The neutron spectral fluence is calculated by MCNP5 calculation very carefully, including all the structures inside the room. The wall-scattering is about 10 % at the 1 m distance from the source. This year, we plan to measure the neutron spectral fluence using Bonner Sphere spectrometer.
This standard has the traceability to the neutron emission rate standards of KRISS.

3. Neutron Spectrometry using multi-sphere system for the neutron dosimetry (Planned)

Recently, KRISS constructed the multi-sphere system for the neutron spectrometry (Bonner Sphere spectrometer), manufactured by Centronic Ltd., UK. The spheres are made of high density polyethylene and He-3 proportional counter (SP9 from Centronic Ltd., UK) is used as a thermal neutron detector.

The Bonner Sphere set has 10 spheres of 3", 3.5", 4", 4.5", 5", 6", 7", 9", 10", and 12" diameter and originally designed by PTB, Braunschweig. The response matrix is calculated by the small modification of original PTB BS's response matrix, considering the difference of the density and the size of the spheres. The normalization of the response matrix is determined by the measurement of the neutron spectrum of ^{252}Cf source.

We plan to start measuring the neutron spectra of the work place field of nuclear power plant.

III. Dissemination of neutron standards

Based on the neutron standards established in KRISS,

- we calibrate the neutron emission rate of the radionuclide neutron source of the emission rate of the order of 10^5 n/s to 10^8 n/s with the uncertainties of ~0.7 %.

In average, we calibrate the neutron source once a year.

- we calibrate about 30 neutron survey meters per year in average.

IV. International Comparison

- the comparison of emission rate, CCRI(III)-K9.AmBe.
- the comparison of neutron survey meter calibrations, EUROMET.RI(III)-S1.

V. Other activities and plans

- We are now planning to measure the mono-energetic neutron fluence using the 1.7MV Tandem accelerator which is located in Korea Institute of Geoscience and Mineral Resources(KIGAM) nearby KRISS.
- We are planning to introduce the neutron spectrometry for the fast neutrons using liquid scintillation counter and spherical proportional counter.
- Long counter will be studied and calibrated for the neutron fluence measurement.
- TEPC was constructed several years ago and it will be revived to measure neutron absorbed dose.
- Neutron transport code (MCNP4C and MCNP5), general Monte-Carlo simulation(GEANT4) could be run to study the neutron detectors, to design the shielding and various structures of the neutron irradiators, to determine the characteristics of the neutron irradiation facility, to determine various correction parameters of the measurement, and eventually to calculate basic parameters for the neutrons.

Staff Members

Two researchers are fully involved for the neutron standardization.
New member will join in this year.

Facilities

- **Radioactive neutron sources**
  two ^{252}Cf source : the emission rates of 2.05×10^8 n/s and 1.95×10^6 n/s
  two ^{241}Am-Be source : the emission rate of 1.229×10^7 n/s and 2.325×10^5 n/s
- **Low background neutron irradiation room** : size of $6.7 \times 7.6 \times 6.4$ m^3
- **Neutron detectors**
  Long counter with one He-3 proportional counter and one BF_3 proportional counter
  two REM counter (EG&G Ortec LB123),
  two H_2 proportional counter
  Liquid scintillation detector (BC501a)

two BF_3 proportional counter
Bonner sphere system with 10 spheres and four He-3 detector
Manganese Sulfate bath system

Publications and Communications

● International

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- **Domestic**

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